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SURVEY OF ANTARCTIC WATER SUPPLY AND WASTE DISPOSAL
FACILITIES, PRACTICES, AND PROBLEMS

BY

LTJG Neil L. Drobny

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**SURVEY OF ANTARCTIC WATER SUPPLY AND WASTE DISPOSAL
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ABSTRACT

Low temperature conditions initiate physical, biological, and chemical changes in the environment. These, in turn, pose significant problems in the design, construction, and operation of facilities for the distribution of water and for the collection, treatment, and disposal of waste. In addition, remoteness is a sizeable problem in the South Polar Region. Distance greatly slows the rate at which material can be supplied for the purposes of construction, maintenance, and repair. As a result, logistics problems assume unusually significant proportions. The need for simple systems is paramount.

A survey of water supply and waste disposal problems at existing United States stations in the Antarctic is presented. Problem areas are identified, and potential research and development efforts are suggested.

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INTRODUCTION

PURPOSE OF THE SURVEY

During the period 29 January to 12 February 1965, the author conducted an inspection trip to various stations in the Antarctic in order to survey the general problem of water supply and waste disposal. The purposes of this report are:

1. To document existing practices
2. To identify problem areas
3. To provide the author's analysis of the problem
4. To suggest possible solutions
5. To identify areas of potential research and development

STATIONS VISITED

The author personally visited the following four United States stations in the Antarctic: (1) McMurdo, the main supply center for United States antarctic operations, (2) Williams Field, the Naval Air Facility serving McMurdo, (3) the NCEL camp on the Ross Ice Shelf, and (4) South Pole Station.

Byrd Station (U.S.), Eighte Station (U.S.), and Hallett Station (U.S.-New Zealand) were not personally visited by the author; information on these stations was obtained, for the most part, by interviewing cognizant personnel. Field personnel were extremely cooperative in helping the author to collect the information for this survey, and the author wishes to acknowledge the assistance of the following persons:

1. RADM James Reedy, COMNAVSUPFOR ANTARCTICA
2. CAPT James Elliott, Commander Task Force 43
3. CDR Stephen Kauffman, Staff Civil Engineer, CTF 43
4. Mr. Phillip Brewer, BUDOCKS Engineer
5. CAPT Christopher Allair, USA, Asst. Staff Civil Engineer, CTF 43
6. LT William Mixon, Medical Officer, McMurdo

7. LT Beazley, MC, OIC, South Pole Station
8. LT William Lederer, MCB-6
9. LTJG David Ross, MCB-6
10. LTJG Walter Stevenson, Plant Superintendent, Nuclear Power Plant, McMurdo
11. LTJG Donald Cornell, Maintenance Officer, Williams Field
12. LTJG David Orr, APWO, McMurdo
13. ENS David Ramsey, MCB-6
14. Mr. Phillip Flash, Technician, Aqua Chem Company

The locations of the various stations are shown in Figure 1.

DEFINITION OF THE PROBLEM

Sanitary engineering problems in the Antarctic are conveniently classified according to two main criteria. One factor is the size of the station; this determines the extent and complexity of the facilities required. The second major consideration is the location of the station. Inland stations present a somewhat different situation than do coastal stations. The unique feature of a coastal station, from a sanitary engineer's viewpoint, is the availability of a large supply of sea water. This in turn is a potential source of fresh water and also a semi-desirable sink for waste and waste water disposal.

In this report, the water supply and waste disposal problems at United States antarctic stations are discussed in terms of the following classifications: (1) the large coastal station, of which McMurdo is the only example, (2) the small coastal station, and (3) the small inland station. In each of these cases, the engineer has a somewhat different set of resources with which to work, and hence he must select a slightly different approach to the problem. The bulk of the discussion in this report will relate to the large coastal station and the small inland stations.

Contributing Factors

It is often considered that low temperature is the sole principle feature distinguishing polar sanitary engineering practices from those employed in the temperate climates. There is even some thought that sanitary engineering projects in the Antarctic should not be radically

different from those normally found in the North Dakota-Minnesota region of the United States. However, low temperatures and the physical, biological, and chemical changes in the environment which result are not the only variants from stateside conditions. Remoteness alone is a sizeable problem in the Antarctic, and so logistics problems assume unusually significant proportions. Virtually all supplies and materials must be shipped or flown from the United States, a distance of some 10,000 miles. Thus, distance alone greatly slows the rate at which material can be supplied for the purposes of construction, maintenance, and repair. Severe weather conditions slow this rate even more. Operations are further retarded by extremely poor local communication and transportation.

The point to be made here is that systems for the Antarctic must be designed not only to withstand the varied effects of low temperature, but also equal attention must be paid to assuring that the local environment can logistically support a given system. The need for simplicity is paramount.

Health Considerations

It is gradually becoming recognized among personnel in the field that low temperatures have a prolonging effect upon environmental pollution. At low temperatures, the metabolic processes of microorganisms are greatly slowed with the result that they can survive for much longer periods of time on a given amount of organic material. Thus, conventional burial and dilution procedures are not effective means for achieving biological self-purification. The result is that pathogenic organisms introduced into the environment today pose both an immediate and a long-range potential health hazard, especially with respect to the contamination of water supplies.

The basic question to be answered concerns the level of environmental pollution which is tolerable. If limited contamination at points well outside existing bases is acceptable, then the only concern need be the safe transmission of waste and waste water from the camp to the disposal site. In this case, conventional burial and dilution procedures would be acceptable disposal methods. Such a policy, however, is unwise for two reasons. First is the potential health hazard to present and future populations. A second consideration is disturbance of the ecological environment which results. Part of the scientific effort of this nation and many others is aimed at investigating the undisturbed antarctic environment. Hence, random waste disposal and the resulting pollution of the environment is by no means in the best interest of our reason for being in the Antarctic.

The other, more idealistic, approach would be to permit no environmental contamination. This ideal has already been reached with regard to radioactive waste from the nuclear power plant at McMurdo. It would be toward achieving this goal that research opportunities would be most abundant, since treatment processes as well as distribution and collection methods would have to be investigated.

Closely allied with the importance of health considerations is the significance of the comfort and aesthetic features of a sanitation program. These factors have a profound influence upon the morale and attitudes of personnel and, hence, upon the operating efficiency of a camp.

LARGE COASTAL STATION - McMURDO

McMurdo Station is located about 2200 miles south of New Zealand. There is installed at McMurdo a prototype nuclear power plant which, due to operational difficulties, has not yet been permanently put on the line. The power plant is 9.51 MW-thermal and 1850 KW-electrical. Power is now being supplied to McMurdo by a new 1500-KW diesel plant.

EXISTING SANITARY FACILITIES AND PRACTICES

Main Camp

The main camp is located on the permafrost of Ross Island adjacent to the Ross Ice Shelf. Temperatures range from approximately -60 F to 40 F, with the summer construction period from October to February having an average in the neighborhood of 13 F. The personnel loading at the station is approximately 1000 persons during the summer and 250 persons during the winter.

Water Supply. In the winter months from March to November, water is obtained by melting snow. Snow melters are installed at the heads, galley, administration headquarters, and science headquarters. The snow melters are operated by gun-type oil burners, the exhaust from which discharges through a coiled pipe. Thermal energy transfer from the pipe to the snow is relied upon to produce the water. A total of six snow melters are in operation with a total average output of about 10,000 gallons/day. Snow is gathered from the surrounding hills about 1 1/2-3/4 mile from town with front end loaders that can haul only enough snow for about 300 gallons of water in one trip.

The only form of overall treatment is diatomaceous earth filtration. In addition, baking soda is added to the drinking water in order to remove an oily taste due to soot from the exhaust stacks of oil-burning equipment. Chlorination is not provided.

In the summer months from December to February (1964-65), water was obtained by damming up a snowbank and collecting the snow melt in a small pond. The water was then tank trucked to the snow melters for distribution within the buildings. In the summer, it would be necessary to travel nearly 2 miles to find snow clean enough for making water.

Waste Disposal. The disposal of human waste and garbage is extremely primitive. The six head buildings are equipped with "honey-buckets" to take care of fecal material. The seats are vented to the outside and are extremely cold and uncomfortable to use. The "honey-buckets" are emptied into a "honey wagon" three times a week, and the contents are hauled to the bay and dumped into the water. Garbage from the galley is collected and dumped in the same manner. During the winter months, a large heap collects which goes out with the ice every spring.

The heads and various other buildings are equipped with crude tin can and sheet metal urinals. Some urinals empty into 55-gallon fuel oil drums which are ultimately hauled to the bay and dumped. Other urinals empty directly to the outside and discharge at grade; in winter, small "amber glaciers" develop. These become quite offensive during the spring melt, when temperatures may range as high as 40 F.

Waste water from the galley is discharged at grade in the general direction of the bay.

Nuclear Power Plant

The nuclear power plant is located on the side of Observation Hill at the south end of McMurdo at an elevation of about 300 feet. The plant is staffed by approximately 20 persons.

Water Supply. Water supply during the 1964-65 summer was trucked to the site from the same pond which served McMurdo. During the 1965 winter, snow will be melted in McMurdo and the water trucked to the plant.

Waste Disposal. The nuclear power plant has the only flush toilet in McMurdo. The toilet discharges into a septic tank in a separate heated building, joined to the main building by heat-traced lines. The setup is shown in Figures 2a and 2b.

The main advantage of the septic tank is that a considerable portion of the solid organic waste is converted to gas. Hence, the organic content of the effluent is reduced and the length of time that organisms will remain viable in the glacier is reduced.

Within the building which houses the septic tank and also a holding tank there is a foul odor, presumably methane and hydrogen sulfide. The effluent discharges from a pipe about 3 feet above grade, and the liquid permeates quite readily into the volcanic ash. During the winter months, a large amber glacier forms.

In October 1964, COMNAVSUPFOR ANTARCTICA became concerned over the potential health hazard of this "sewage glacier." Laboratory tests at 4 C (39.2 F) using various nutrients failed to indicate any bacterial growth from the sewage glacier material; however, tests at 37 C (98.6 F) resulted in the growth of a harmless bacterial species normally encountered among intestinal flora.¹ These results are exactly what one should expect. The indication is that had pathogenic organisms been present in the original waste, they would have remained viable, and hence would have constituted a very definite potential health hazard. However, the analyst who did the work chose to define a potential health hazard quite loosely as, "a condition wherein the material in question remains at or exceeds the original capability to introduce deleterious organisms into the human body thru normal environmental transmission." Hence, it was concluded, almost by definition, that the glacier does not constitute a potential health hazard. As a result, no one is concerned about this potentially dangerous condition.

Radioactive waste generated by the reactor is low-level in nature; it is concentrated and shipped to the states for disposal.

PLANNED IMPROVEMENTS

There is currently under construction at McMurdo a conventional community liquid water distribution and water-carriage sewage collection system. The system is being installed above ground in 21-foot-long sections and is provided with electric heat tracers. The system is constructed of flanged copper piping insulated with 3-1/4 inches of polyurethane foam and covered with a steel jacket on the outside.

The system is very complex when viewed in relation to the other facilities at McMurdo. The system was scheduled for completion at the end of the 1964-65 summer, but various design and construction problems have arisen which, in the author's opinion, may prohibit full-scale operation for several years. Specific problem areas will be discussed later.

Water Supply

A desalinization unit has been installed adjacent to the nuclear reactor unit. The unit became operational in mid-February 1965 and will probably be put into full use at the beginning of the 1965-66 summer. Until the new water distribution system is operational, water will be distributed by tank truck to the snow melters. Present plans are to continue the use of snow melters in the winter months.

The desalinization unit is a 16-stage flash evaporator designed by Aqua Chem Co. The unit is designed to operate using nuclear steam, but is currently operating from a diesel powered steam boiler. The unit produces 10 gpm of fresh water with a chloride content of 4.5 ppm; 9.6 gallons of sea water are required to produce 1 gallon of fresh water. The daily capacity of this unit is 14,400 gallons, which will yield, in the summer months, about 15 gallons per person per day. Provision is made for a second unit which would double this supply. A schematic diagram showing the overall system is shown in Figure 3.

At the end of the 1964-65 summer, the sea water intake and the brine return lines between the pump house and the plant, and part of the fresh-water distribution line from the plant to McMurdo had been completed. Figure 4 is a view of the nuclear power plant and desalinization unit taken from McMurdo; in the foreground are the USARP buildings at the southern end of McMurdo; the completed water lines are also visible.

Waste Disposal

Construction has not yet begun on the sewer lines, but when the new system is finally complete, McMurdo will be served by flush toilets. Head buildings in the lower part of town and a new personnel building (yet to be built) containing a galley, laundry, and barracks, will be the first areas served. The attempt is being made to concentrate most of the waste and waste water producing functions in the lower part of town. Fresh water from the desalinization plant will be used as the flushing medium.

The waste will be discharged from the collection system into the bay about 5 feet above grade so as to prevent ice build-up which would clog the outlet. This outfall is about 1/2 mile from the sea water intake to the desalinization unit; a study of water movement in the bay indicates that contamination of the water supply is unlikely. Additional safety is insured by the fact that pasteurization conditions are achieved within the desalinization unit.

It is anticipated that when and if any form of treatment is provided that it will be the high rate aeration process.

Current Experimental Efforts

Polar Toilet. An experimental unit has been installed in one of the McMurdo heads for evaluation during the 1965 winter. The unit contains two seats and one urinal and was designed and fabricated under the direction of NCEL.² The unique feature of the unit is that it continues to recycle and re-use the flushing medium. The unit is initially charged with 18 gallons of water and 2 pounds each of cupric sulfate pentahydrate granular and sodium bisulfate. The unit will be used on a daily basis as supply and maintenance capabilities permit. The unit will be discharged at grade in the general direction of the bay. The installed unit is shown in Figure 5.

Disposable Plastic Bags. It is planned to modify the honey-buckets during the 1965 winter by installing a disposable plastic bag directly from the seat into the bucket. This will eliminate the direct vent to the outside and should eliminate some of the discomfort associated with the use of the honey-bucket. The bag will be removed periodically and tied shut for disposal on the ice.

DISCUSSION

Present System

The existing water supply seems to be moderately satisfactory, at least more so than the waste disposal system. The main problem with the dammed-up pond in the summer was quantity and to some extent, quality; snow melters should be able to keep up with the demand during the winter. The desalinization plant should soon resolve all water supply problems.

The honey-buckets and the randomly discharging urinals are totally inadequate. The potential health hazard of the system is apparently underestimated by most personnel. Honey-buckets are emptied quite carelessly and material spills onto the ground. As indicated earlier, some urinals also discharge directly onto the surface. The opportunities for human contact with the waste are numerous. Pathogenic organisms could very easily be picked up on boots and tracked indoors where high temperatures would stimulate rapid growth; infection of personnel would readily follow.

The absence of flies, mosquitos, and other common vectors stimulates a sense of security. However, the role of the skua gull as a potential vector should not be overlooked. These birds naturally frequent the dump area, and should they also visit the area from which snow is collected for melting, personnel might easily pick up pathogens from drinking water.

This system should be eliminated as soon as possible, without waiting for the planned community system to become operational.

Planned Community Water Distribution and Sewage Collection System

BUDOCKS is fairly well committed on the type of the system to be provided. Once this determination is made, many of the problems fall into the realms of design and logistics. This author feels that construction and design problems will be so compounded by the logistic support and maintenance requirements that the system may not be operational for several more seasons. BUDOCKS has recently visited McMurdo and modifications may be forthcoming.

The main problem areas which have been associated with the system to date are:

1. The timber carriages for the sea water, brine return, and fresh-water lines to and from the desalinization unit constructed during the 1963-64 summer had to be rebuilt during the 1964-65 summer. The original design required that all of the 21-foot sections of pipe be supported at their centers by timber carriages. During the 1964 winter, considerable movement and shifting of the lines occurred. During the 1964-65 summer, the lines were rebuilt with timber carriages at the ends of each pipe section. How the lines will fare during the 1965 winter remains to be seen. A typical pipe section, showing the timber carriage supports, is shown in Figure 6.

2. Problems with burned-out heat tape were experienced in the completed sea water intake and brine return lines in the summer of 1964-65. The problem was attributed to a lack of proper thermostatic control which has since been provided. In addition, the original heat tape has been replaced with a more durable product.

3. The sea water intake system has not yet been perfected. During the summer of 1964-65, a 4-inch rubber hose was connected to the pumping system and merely immersed in the water. The design calls for a series of floating rafts, fabricated from empty fuel oil drums which will extend

about 80 feet from the shore line into the bay. Suspended from these rafts will be a large valve. The valve will extend to a depth sufficient to be free from the annual freezing. The system was almost 100 percent complete at the end of the 1964-65 construction season. The problem stems from a very real possibility that the next time the annual ice goes out, the entire system will be torn loose and lost to the sea. Another potential problem is that the pump house is constructed partially on ice and it, too, may some day break loose.

4. A problem envisaged with the sewage collection system is that of maintaining enough flow to carry away the solids. Water use will be limited, and so flows in the pipelines will be kept to a minimum.

These, then, are the problem areas which have arisen to date. Unfortunately, one must expect others to arise as construction progresses.

FINDINGS

The author found that most of the personnel concerned with the general sanitation problem share two main feelings. There is hearty agreement that the present system is inadequate. There is also a sizeable body of opinion that the community system under construction might be too complex for both the level of technology and the logistic capabilities of present-day McMurdo.

It appears that a research program should precede the installation of a community system. This approach to the problem would help to eliminate the costly lessons of trial and error which have occurred and which can be expected to continue to occur.

Regardless of which approach is taken, that of designing a system based on research findings or that of building a system based on trial and error construction in the field, it appears that a truly serviceable community system will not soon be operating in McMurdo. Hence, a real need exists for an interim system to bridge the gap between the present honey-bucket system and the future ideal community waste collection system.

Another area in need of improvement concerns the efficient use of water. The present plan to use fresh water as a flushing medium seems extremely unwise in view of the cost and scarcity of good water.

A final need is for more efficient use of energy. Engineering design considerations would no doubt increase the efficiency of the

existing snow melters. It would also be wise in McMurdo to use generator waste heat as a source of energy for melting snow; this technique is employed at some of the outlying stations.

SUMMARY OF PROBLEM AREAS AND POTENTIAL SOLUTIONS

Community Water Distribution and Sewage Collection Systems

1. Additional research is required to perfect the design and construction of heated liquid distribution systems for polar regions. Continuation of NCEL Task Y-F015-11-01-195, "Distribution of Liquids," would seem to serve this purpose.

2. A task might be instituted aimed at developing new concepts and techniques for the distribution and collection of water and waste water. Two such thoughts which have occurred to the author are discussed briefly below.

a. Liquid Brine Waste Carriage. A waste collection system might be developed wherein the transporting medium would be a concentrated, antifreeze, brine solution. Waste deposited into the system would both freeze and float, and hence facilitate easy separation at an appropriate place. Re-use of the transporting medium would be a key feature.

b. Pneumatic Transport. Thought should be given to finding means to turn the "cold" from a disadvantage to a real asset. One such technique might be to transport liquids in the frozen form, as snow or ice, by a pneumatic conveyor, as opposed to the conventional liquid form by a heated pipeline.

Rough theoretical calculations indicate that the energy requirements for such a system would be on the order of 2.5 watts per lineal foot.

It should be emphasized that systems such as those discussed above are indeed too complex for present-day McMurdo. They may, however, be quite appropriate for the McMurdo of the future or for other large stations which might be planned.

3. Techniques and concepts should be investigated for achieving the efficient use of water.

The first stage of the investigation should study the feasibility

of using sea water, brine from the desalinization plant, wash water from the heads and laundry, or waste water from the galley as a flushing medium.

Still another means of conserving water would be to develop a toilet that would flush efficiently using only 1 to 2 gallons of water. A standard commode serviced by a modified water closet would probably not be satisfactory.

From here, the investigation might be extended to develop and/or evaluate techniques for the re-use of waste water. The United States Public Health Service is conducting extensive work along this line which might be monitored.

4. McMurdo would especially benefit from a program aimed at developing reliable techniques for getting salt water from the sea. The development of adequate sea water intakes for use in the polar regions has received very little R&D effort.

Interim Waste Collection and Disposal System

Desired Features. An interim system to bridge the gap awaiting the development of an operational community system should have the following features:

1. Easily fabricated at McMurdo from readily available parts and pieces. A minimum of special parts should be required.
2. Capable of immediate fabrication and installation by Seabees at the beginning of DF-66.
3. Minimum or no use of fresh water should be required. Maximum economic use should be made of sea water, brine, and various forms of waste water as a flushing medium.
4. System should be simple and inexpensive to operate.
5. System should be capable of easy transition to the planned community system which is presently under construction with:
 - a. Minimum of effort
 - b. Minimum of wasted material

6. Opportunities for human contact with waste material should be minimized. There should be no release or spillage of waste into the immediate camp environment.

7. System should be comfortable to use and aesthetically appealing.

Proposed System. The system described below is suggested by the author to satisfy the criteria outlined above. The system is not especially unique; rather, simplicity is the main advantage.

Selected head buildings in McMurdo would be outfitted with flush toilets. These toilets should preferably, but not necessarily, be of a type that would flush efficiently using only a gallon or two of water. In addition, each head building would be equipped with two large tanks fabricated, if necessary, from empty fuel oil drums. One tank would store the flushing medium prior to use; the second tank would receive the mixture of waste and flushing medium after use.

The flushing medium would be waste wash water from whatever source is available, complemented with sea water or brine as demand required; the required sea water or brine would be delivered by tank truck.

Once a day, or as demand requires, the second stage tanks would be pumped empty of the flushing medium and waste, and tank trucked to the bay for disposal. A schematic diagram of this concept is shown in Figure 7.

Conversion to the community system would be possible without dismantling the interim system. Hence, two additional advantages are inherent in the system. It would continue to serve as a back-up system should the community system suffer a malfunction. In addition, the tank trucks required would also double as a fire-fighting force.

Installation and operation of the system would require a certain investment of both equipment and manpower, the exact magnitude of which remains to be evaluated.

SMALL COASTAL STATIONS

Williams Field and Hallett Station are the only stations of this type in which the United States has a direct interest. Sanitation problems at these facilities are less pressing than at McMurdo, mainly due to the smaller population which must be supported.

WILLIAMS FIELD

Williams Field is the air facility serving McMurdo. It is located about 1 mile southwest of McMurdo on ice of the Ross Ice Shelf about 30 feet thick. About 250 persons are stationed at Williams Field during the summer construction season. The facility is closed during the winter.

Existing Water Supply

Water is obtained at Williams Field by melting snow; two head buildings and the galley are served. Snow is hauled from a remote area about 100 yards from camp and delivered to the vicinity of the snow melter after which it is hand shovelled into the snow melter. This hand shovelling is about a 24-hour-a-day job to keep up with the daily demand of 5000 gallons or about 20 gallons/man. The snow melter is followed by a diatomaceous earth filter but no chlorination.

Existing Waste Disposal

Waste disposal at Williams Field somewhat resembles that at McMurdo. Honey-buckets are used and are dumped along with trash and garbage about 1000 yards from camp. The waste is periodically covered with snow. Most of the buildings are equipped with urinals which discharge at grade to the outside. Waste water from the heads and galley discharges through a hole in the ice to the sea water below.

An attempt has been made to provide one head building with a sea water, continuously flushing toilet system. Two holes are bored in the 30-foot ice. Sea water is pumped up one hole, delivered to a sloping trough over which a row of seats is built, and discharged along with the waste material through the second hole back into the sea. Freezing of the intake has been a considerable problem, and the system has been operational only on occasion. Crude heat taping has not resolved the problem. An effort may be made in the 1965-66 summer to provide more adequate heat taping and thus eliminate the problem.

Planned Improvements

BUDOCKS has designed a prefabricated head building for Williams Field using eight standard size wanigans. The overall unit contains a snow melter, distillation unit, showers, urinals, and a salt water flushing system.

Two units of this type have been delivered to McMurdo and are scheduled to be put into service at the beginning of DF-66.

Discussion

The main problem with the water supply system is limited quantity. The problems with the waste disposal technique are: (1) the potential health hazard of the open dumping, (2) the discomfort involved in the use of the honey-buckets, and (3) pollution of the ecological environment. Development of a reliable sea water intake system so that the continuously flushing system could be operated would significantly improve the situation. Installation of the wanigan head units may well solve all the problems except that of environmental pollution.

HALLETT STATION

Hallett Station, located about 500 miles north of McMurdo on the entrance to the Ross Sea, is a small station operated jointly by the United States and New Zealand. The peak population is about 70 persons, but after the runway closes in December, the average population drops to about 17. This discussion of the sanitary facilities at Hallett is included mostly in the interest of completeness.

Existing Water Supply

The lack of continued snow cover at Cape Hallett and potential contamination by penguin wastes renders snow melting impractical. In the summer months, melt water is collected from a glacier about a mile from camp. It is then hauled to the station where it is pumped into various storage tanks in the buildings. During the winter, sea water is converted to fresh water using two 85-gph distillation units.

Average water consumption is about 20 gallons/man/day.

Existing Waste Disposal

Honey-buckets are also in use at Hallett. All waste material, including trash and garbage, is dumped into the sea. Galley waste water and urinals discharge directly to the outside at grade.

Discussion

Water supply again seems adequate except for quantity. The main fault with the waste disposal technique, other than inconvenience, is the rather low-level pollution of the land and ocean environments. Perhaps some type of sea water flush toilet would add to the convenience aspect.

FINDINGS

The attempt is being made at both Williams Field and Hallett Station to take maximum advantage of the existing sea water supplies. The main water supply problems are: (1) limited quantity and (2) perhaps the need for a reliable sea water intake device. The main waste disposal problems are inconvenience and pollution of the ocean environment. Re-use of waste water might be a future potential solution to both of these problems.

In general, there appear to be no problems which are not receiving just attention.

SUMMARY OF PROBLEM AREAS AND POTENTIAL SOLUTIONS

There appear to be no glaring opportunities for any sizeable effort aimed solely at the problems of Williams Field and Hallett Station. The problems faced by these two facilities are faced perhaps more so either at McMurdo or at the inland stations discussed in the next section. Hence, it is suggested that no specific attention be given to these small coastal stations, but rather that future developments for the other types of stations be monitored and adapted for use in these areas.

SMALL INLAND STATIONS

Inland stations in the Antarctic are characterized by (1) a lack of any naturally occurring water during any portion of the year and (2) relatively small populations.

SOUTH POLE STATION

The South Pole Station was originally constructed above ground on about 5000 feet of snow; however, snow accumulation has since buried most of the station, and all the buildings are now connected by underground snow tunnels. The personnel loading at the station is about 40 persons in the summer and 15 persons in the winter.

Existing Water Supply

The water supply at the South Pole Station is obtained by snow melting. Two snow melters, using hot exhaust gases from diesel generators, are used to supply two gravity feed storage tanks. The water distribution lines in the tunnels are 1-inch pipe on about 4:1 slope; they are kept drained when not in use to prevent freezing.

Drinking water is passed through a diatomaceous earth filter and is treated with baking soda to remove an oily taste. The average water consumption is about 50 gallons/man/day. This high consumption results from the use of flush toilets and an automatic clothes washer.

Existing Waste Disposal

The heads are equipped with conventional 5-gallon flush-type toilets. The waste water from these units along with that from the urinals and washing machine is discharged into a pit in the snow. The extent or size of this pit is not at all known. The heat in the waste water is sufficient to keep the system open.

Waste water from the galley discharges to a similar pit about 35 feet deep. Freezing problems are experienced with this pit, and 100-pound doses of caustic soda are added as required. The extent of this second pit is also unknown except that traces of waste water were discovered in a snow mine only 50 feet away, which was once used to obtain snow for melting. This, in turn, required that snow be gathered from the surface.

Trash and garbage at the South Pole Station are burned in an incinerator located at the end of a tunnel.

Planned Improvements

There is some thought being given to installing a Rodriguez Well during the 1965-66 summer. This would greatly simplify the task of obtaining water.

A replacement facility for the entire South Pole Station is planned for FY-67 through FY-72; the basic design for the facility was done by NCEL.³ No significant change from the existing type of sanitary facilities is planned for the new station.

Discussion

The existing facilities are quite adequate from the comfort standpoint. The use of the 5-gallon, fresh water flush toilets seems unwise. It would seem more logical to use some form of waste water as a flushing medium. Another improvement would be a flush toilet that used only 1 to 2 gallons per use.

The biggest potential problem is the waste water disposal pits. Since their extent is unknown, the contamination of present and future water supplies is a real possibility. Another point to be considered is that such pits might very well undermine portions of the camp and thereby cause structural failures.

The construction of the new camp could be an ideal opportunity to test new water supply and waste disposal concepts for use in the inland stations.

BYRD STATION

Byrd Station is located approximately 500 miles east of McMurdo. The station was completed in 1961 and was built entirely underground on an existing snow depth of about 5000 feet. The personnel loading at the station is approximately 100 persons in the summer and 25 persons in the winter.

Sanitary facilities and problems at Byrd Station are similar to those at the South Pole Station. Since the author did not actually visit Byrd Station, Reference 4 is heavily relied upon in the following discussion.

Existing Water Supply

Water supply is obtained by melting snow; snow is collected from a remote area about 1/4 mile upwind from the station. From here, it is hauled by sled to the station and delivered to the snow melter by means of an inclined belt conveyor. Cooling water for the diesel generators is used as a source of energy for melting the snow. All water is filtered through diatomaceous earth filters before consumption.

A looped, continuously circulating distribution system serves each building. Piping inside the buildings is exposed to absorb heat from the building; pipes outside the buildings in the tunnels are electrically traced.

Existing Waste Disposal

Flush toilets are also installed at Byrd Station. Waste and waste water is collected from the various buildings by a 4-inch pipe-line which empties into a heated and insulated sump. From here, the water is pumped to two disposal pits in the snow. The size and extent of these pits is not known.

Planned Improvements

The only existing plans for additional facilities at Byrd Station are for a Rodriguez Well. A well may be installed during the 1965-66 summer.

Discussion

The only problems with the water supply system are the inconvenience and effort required to gather the snow which, in turn, results in a limited supply.

As at the Pole Station, the biggest problems with the waste disposal system are the contamination of the snow environment and possible loss of structural support due to the waste disposal pits.

EIGHTS STATION

Eights is a very small station about 1500 miles east of McMurdo; the station is located on about 5000 feet of snow and was constructed in the 1962-63 summer. The peak population in the summer is no higher than 20; the winter population is eight. The following brief discussion of the sanitary practices at Eights Station is included solely in the interest of completeness.

Water is obtained by snow melting and good, clean snow is abundant. Waste water is drained to the outside to a large pit in the snow. Trash and garbage are burned and buried.

NCEL CAMP

The U. S. Naval Civil Engineering Laboratory operates a research field station about 5 miles southeast of McMurdo during the antarctic summer. The main living and work area consists of three Jamesway huts; personnel loading at the camp averages about 20 persons.

Existing Water Supply

Water is obtained by melting snow. An oil-fired hot water heater is used to make hot water which, in turn, is used to melt the snow. Snow is gathered by a front end loader and dumped directly into the snow melter. The average demand ranges from 200 to 250 gallons per day or about 10 to 12 gallons/man/day. This demand is satisfied by about 2 hours daily operation of the snow melter. Hence, because the camp is small and efficiently operated, quantity is not really a problem. Water is supplied to storage tanks in the two living and office quarters by means of a retractable rubber hose. All water is mechanically filtered to remove particulate matter and is passed through charcoal filters to remove foul taste and odor.

Existing Waste Disposal

The galley waste water is discharged to the snow outside. No attention is paid to its ultimate destination; all that is known is that it seems to disappear into the snow quite readily - presumably melting out a large undersnow cavity in the vicinity of the galley building. Wash basins and urinals in the living spaces also discharge freely to the outside without further attention.

A pit privy, consisting of an uninsulated building with two seats constructed over two 15-foot pits in the snow, serves the camp. When the pits fill up, the building shall be moved to a new location. Needless to say, the facility is extremely uncomfortable to use. Garbage is hauled to a surface pit on the perimeter of the camp where it is periodically burned and covered with snow.

Planned Improvements and Experimental Efforts

There are no active plans for any modification to the existing facilities. The camp is, however, designed to test new concepts, and some thought is being given to installing some type of flush toilet so as to eliminate the inconvenience associated with the present system.

Discussion

As indicated earlier, neither quantity nor quality of the water is a real problem. Hence, a flush toilet would indeed be quite simple to install. This would be a good place to evaluate two concepts presented earlier with regard to the needs of other stations. Specifically, these are: (1) a flush toilet designed to operate on a 1- to 2-gallon charge, and (2) the use of waste water (galley, shower, etc.) as a flushing medium.

The existing privy building could be modified quite easily to serve as a head building. All that would have to be added is some insulation, a small heater, a few flush commodes, and a storage tank for the flushing medium. The waste would then be discharged to an open pit in the snow as is done at Pole and Byrd Stations.

FINDINGS

Water supply at the inland stations quite logically is obtained by melting snow. The main problem with the system is the effort and inconvenience involved in collecting and transporting the snow to the station. These factors coupled with the limitations of existing equipment generally limit the water quantity available.

Flush toilets are nearly a reality in every inland station. Further development and new concepts might well improve the existing facilities and make new ones feasible. The major fault with the existing flush toilets arrangement is that a large quantity of fresh water is used for each flush.

The disposal of solid waste and waste water to the surrounding snow is universally practiced by all inland camps. The main problems associated with this practice are: (1) potential health hazard to present and future personnel, (2) the potential loss of structural support due to the creation of large below-grade cavities, and (3) contamination of the snow environment to such an extent that certain scientific investigations will not be possible.

SUMMARY OF PROBLEM AREAS AND POTENTIAL SOLUTIONS

New concepts are needed to further increase the efficient use of water. A minimum flush toilet is needed. In addition, various forms of waste water might be employed as a flushing medium in place of fresh water.

Depending on the extent of BUDOCKS interest in minimizing or eliminating the contamination of the snow environment, a program might be instituted to study the problem. This implies some form of treatment aimed at either rendering inert the large quantities of waste and waste water generated, or eliminating the need for the disposal of the waste material. One technique for achieving the latter would be the re-use of waste water; this, in addition, would also eliminate the need for melting snow and the disadvantages inherent therein.

POTENTIAL RESEARCH AND DEVELOPMENTS EFFORTS

LIQUID WATER DISTRIBUTION SYSTEMS

Additional research is needed to perfect the heated pipelines for community liquid water distribution and water-carriage sewage collection systems. Developments in this area would have immediate application to the system currently being installed in McMurdo. NCEL is currently conducting work of this type.

NEW CONCEPTS IN WATER AND WASTE WATER DISTRIBUTION AND COLLECTION

Alternatives to the conventional community systems should be explored. Efforts should be aimed at finding ways to turn the "bald" from a disadvantage to an advantage. The pneumatic transport system and the liquid brine waste collection system described in this report are two such alternatives conceived by the author; no doubt further study would generate others.

SEA WATER INTAKE

A reliable sea water intake system will be needed by McMurdo if the present raft system goes out with the ice. Since the Navy has not had considerable experience with systems of this nature, research and development studies should precede design and installation. Studies in this area might also be of use in the small coastal stations as well.

EFFICIENT WATER USE

Considering the scarcity and the expense and effort required to obtain good fresh water, concepts and techniques should be developed to insure maximum efficient use.

1. The feasibility of using sea water, brine, and various forms of waste water as a flushing medium should be explored.
2. The development of a toilet designed to flush using only 1 to 2 gallons of water would help to conserve water in every station equipped with flush toilets.
3. The polar toilet described in this report is an effort in this direction. Studies to effect the re-use of the flushing medium should continue as a part of the overall water conservation program.

ELIMINATION OF ENVIRONMENTAL CONTAMINATION

Contamination of the snow and ocean environments is the main problem with the existing waste disposal practices. Techniques should be developed for minimizing the discharge of organisms and/or biodegradable organic matter to the environments.

RE-USE OF WASTE WATER

Reclamation of waste water may hold some yet unrealized potential for the solution of many of the sanitation problems in the Antarctic. The Robert Taft Sanitary Engineering Center of the United States Public Health Service is conducting extensive work along this line which could be monitored to aid in formulating a basis for a BUDOCKS program.

Some of the problem areas which would benefit from a re-use system are:

1. Elimination of source and/or supply problems. Need for snow melting and sea water intakes could be essentially eliminated except for make-up water requirements.
2. Waste treatment possibilities would be greatly enhanced since extraction of solids and sterilization of waste would be a by-product

of the process. Contamination of the environment, hence, would cease to be a problem.

3. Single premise systems may be possible which would eliminate the need for transporting water and waste water outside the buildings.

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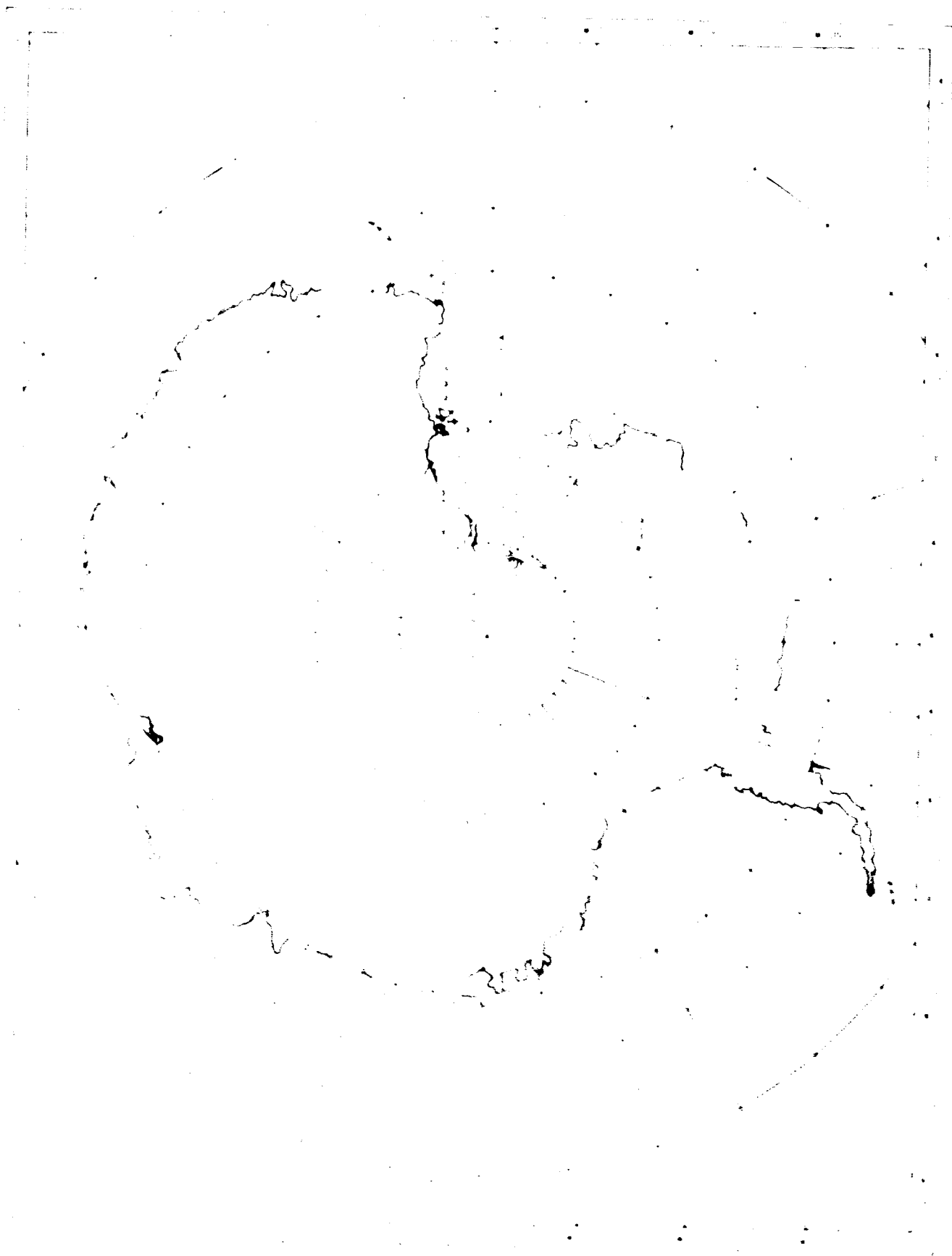


Figure 1. Map of South Polar Region.

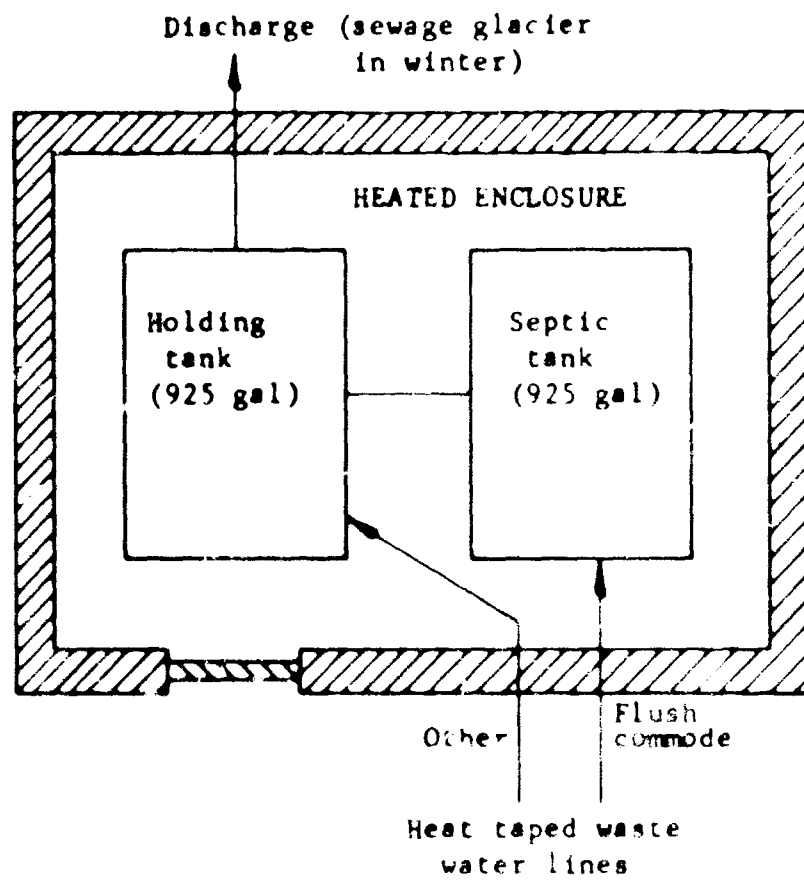


Figure 2a Septic tank system at nuclear power plant



Figure 2b Heat-taped waste water line connected with septic tank building

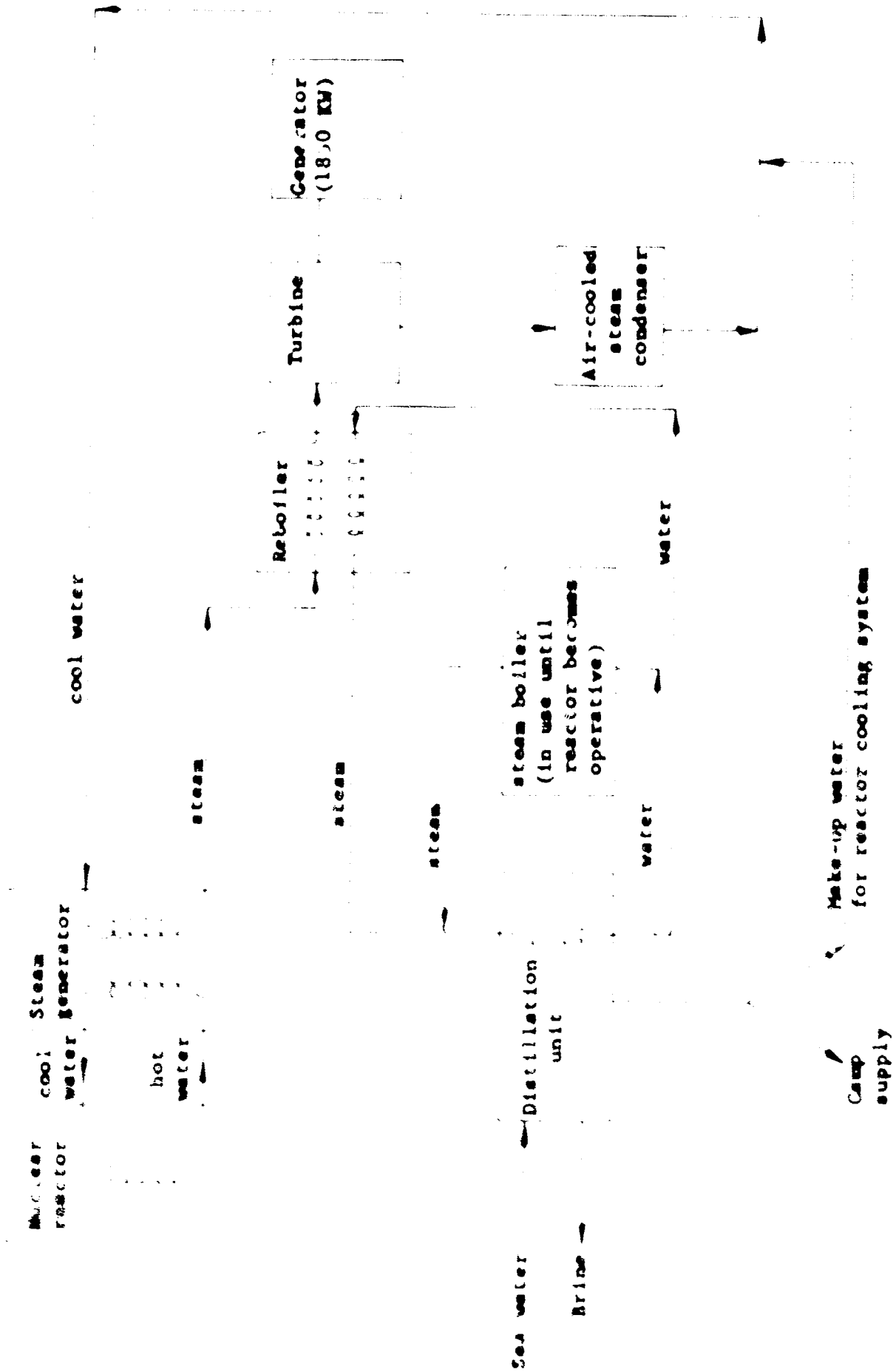


Figure 3. Desalination of sea water at McMurdo.



Figure 4. View of nuclear power plant and desalinization unit from McMurdo.



Figure 5. Polar toilet installed in a McMurdo head.



Figure 6. Typical pipe section showing timber.

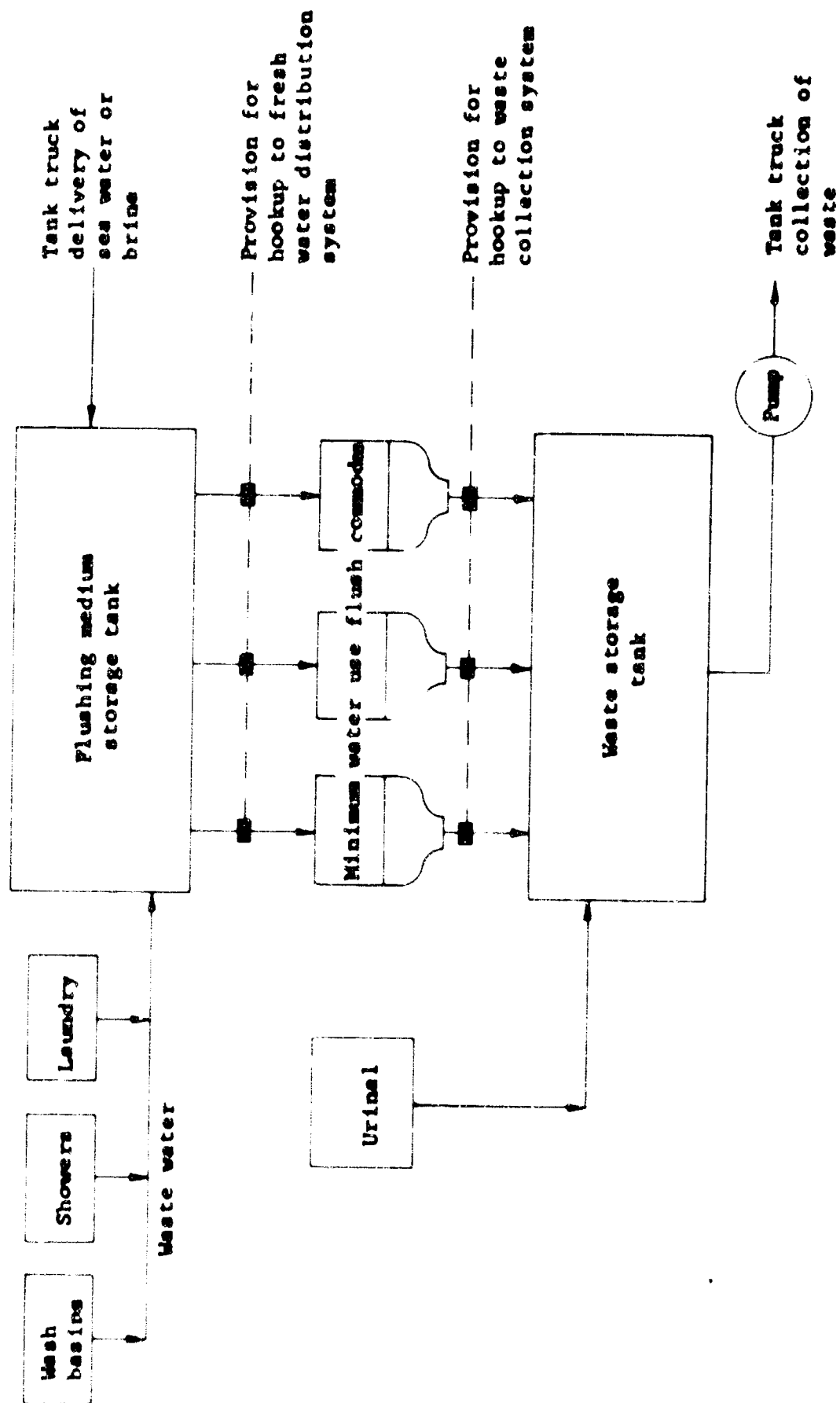


Figure 7. Concept of interim waste collection system for McMurdo.